5. POTENTIAL FOR HUMAN EXPOSURE

5.1 OVERVIEW

1,1,2,2-Tetrachloroethane is a synthetic chemical not known to occur naturally (IARC 1979). It has been used as a chemical intermediate in the production of chlorinated ethenes, as an industrial solvent and extractant, and in a few pesticide preparations. Its production as an end-product declined markedly after the late 1960s; by the early 1990s manufacture as an end-product ceased both in the United States and in Canada (CEPA 1993). Present sources of 1,1,2,2-tetrachloroethane are largely attributable to fugitive emissions or discharges when it is generated as a by-product and emissions or discharges stemming from its production and use as a chemical intermediate.

The major releases of 1,1,2,2-tetrachloroethane are to the atmosphere and surface water, with very small amounts now being land-applied. If released onto soil, some of the chemical would be expected to volatilize, with the remainder leaching into the subsurface soil profile and, possibly, groundwater. If 1,1,2,2-tetrachloroethane is released to surface water, part of it would volatilize, with the remainder dissolving in water where it would undergo degradation through hydrolysis. In groundwater, the major degradation processes involve anaerobic biodegradation and chemical hydrolysis. Chemical hydrolysis is very sensitive to pH and is much faster under basic or neutral conditions. Trichloroethylene is the major, if not the sole, product of chemical hydrolysis. Half-lives for chemical hydrolysis reported at neutral pHs range from 29 to 102 days. Biodegradation proceeds by dehydrodehalogenation; products of biodegradation include trichloroethylene, 1,2-dichloroethene, and the highly toxic vinyl chloride.

In the ambient air, the dominant process for removal of 1,1,2,2-tetrachloroethane is the reaction with photochemically generated hydroxyl radicals, with an estimated half-life of 53 days (Atkinson 1987). Older studies, based primarily on theoretical calculations combined with laboratory experiments, have suggested residence times in the lower atmosphere with half-lives greater than 2 years (HSDB 1996). Removal also should occur through washout by precipitation; however, most 1,1,2,2-tetraehloroethane removed by this mechanism will likely reenter the atmosphere by volatilization. Atmospheric degradation of 1,1,2,2-tetrachloroethane is slow enough to allow considerable dispersion from source areas both within and outside of the United States. Slow diffusion into the stratosphere will also occur. Releases to surface water will mostly be lost by volatilization with a half-life of around

6.3 hours (HSDB 1996; Thomas 1982). Theoretical considerations and experimental results indicate that adsorption to sediment and bioconcentration in fish will not be significant (Verschueren 1983).

The general population may be exposed to 1,1,2,2-tetrachloroethane by inhalation of contaminated air; however, evidence from monitoring data (Class and Ballschmiter 1986) suggests that exposure levels are extremely low. It is difficult to assess occupational exposures because data on current production and use are not available. A National Occupational Exposure Survey (NOES) by NIOSH through May 1988 estimates that 4,143 employees are potentially exposed to 1,1,2,2-tetrachloroethane in the United States (NOES 1991). Occupational exposures, while low, are primarily via inhalation and dermal contact.

1,1,2,2-Tetrachloroethane has been identified in at least 273 of the 1,430 current or former NPL hazardous waste sites (HazDat 1996). However, the number of sites evaluated for 1,1,2,2-tetrachloroethane is not known. The frequency of these sites can been seen in Figure 5-l.

5.2 RELEASES TO THE ENVIRONMENT

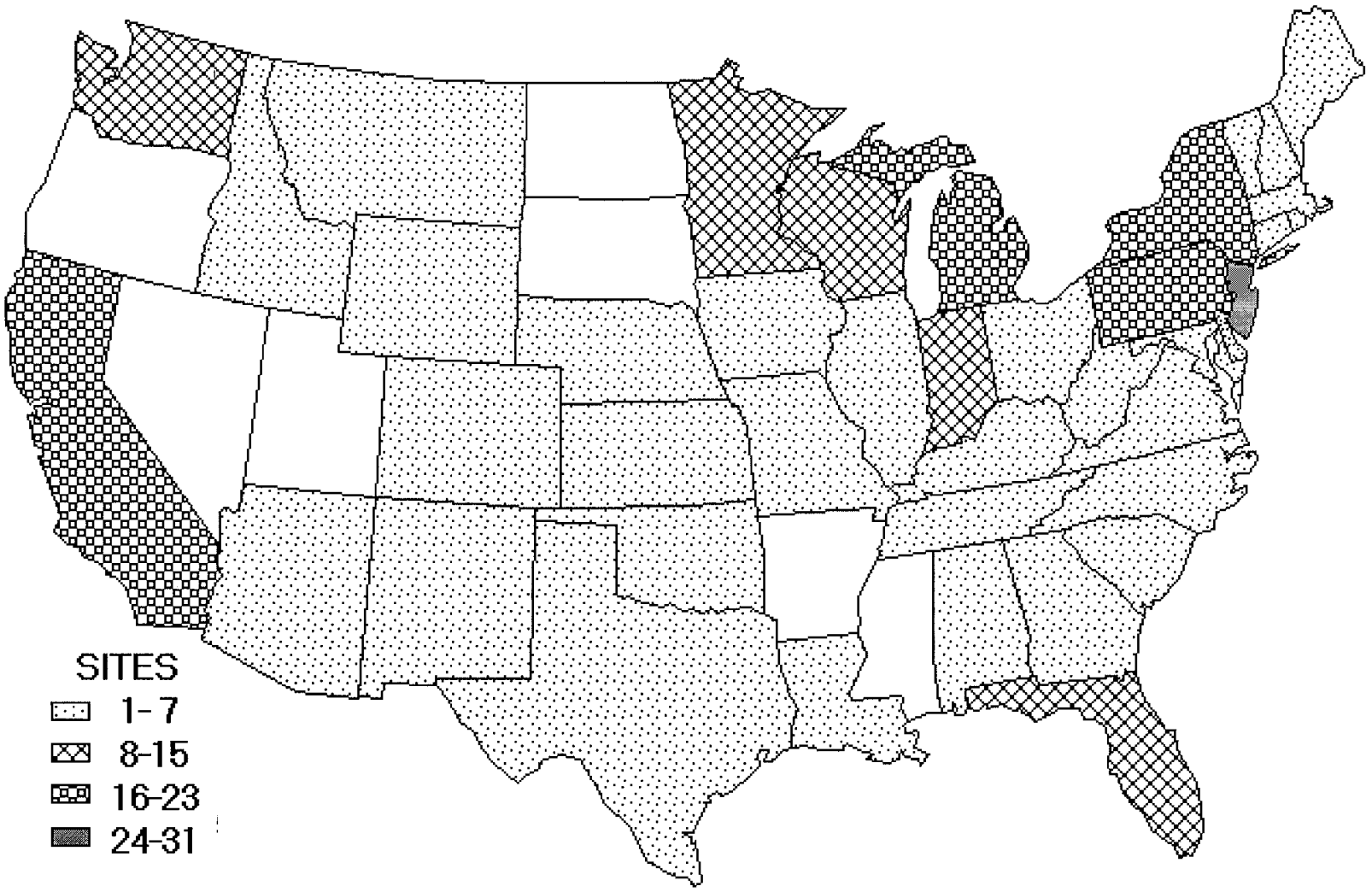
Table 5-l lists releases to the environment from facilities that manufacture or process 1,1,2,2-tetrachloroethane. The data in Table 5-l are derived from the Toxics Release Inventory (TRI) and refer to releases in 1993 (TR193 1995). Because only certain types of facilities are legally required to report, this list is not exhaustive. Of the 15 reporting facilities, 7 are located in Louisiana and 4 are located in Texas. The limited available data do not allow precise estimates of trends in releases to the various environmental media.

5.2.1 Air

1,1,2,2-Tetrachloroethane has been released into the air during the process of manufacturing trichloroethylene from acetylene or during use as a metal degreasing agent; as a paint, varnish, and rust remover; and as an extractant, solvent, and chemical intermediate (Verschueren 1983). It may also be emitted from hazardous landfills (Harkov et al. 1987).

1,1,2,2-Tetrachloroethane was one of the 10 most prevalent chlorinated chemicals found in solvent wastes that were incinerated each year prior to 1980 (Travis et al. 1986). A study was performed to

Figure 5-1. Frequency of NPL Sites with 1,1,2,2-Tetrachloroethane Contamination



Derived from HazDat 1996

Table 5-1. Releases to the Environment from Facilities That Manufacture or Process 1,1,2,2-Tetrachloroethane

State [b]	Number of facilities	Range of reported amounts released in pounds per year [a]						
		Air	Water	Land	Underground injection	Total environment [c]	POTW transfer	Off-site waste transfer
KY	1	90	0	0	0	90	0	11
LA	7	100-11600	0-520	0-1	0	100-12121	0	0-1566936
NJ	1	45	0	0	0	45	150	42000
SC	1	500	0	0	0	500	5	1500
TN	1	330	1	0	0	331	0	0
TX	4	0-13550	0-2400	0	0	0-15950	0	0-118835

Source: TRI93 1995

[a] Data in TRI are maximum amounts released by each facility.
[b] Post office state abbreviations used
[c] The sum of all releases of the chemical to air, land, water, and underground injection wells by a given facility

POTW = publicly owned treatment works

ascertain the annual emissions of these chlorinated chemicals from a hypothetical 4,400 kw rotary kiln incinerator, with each chemical being represented according to its fraction in the stack of the incinerator. Annual stack emissions of 1,1,2,2-tetrachloroethane from such an incinerator were estimated to be 7.1 kg, assuming a standard destruction and removal efficiency of 99.99% and a waste throughput of $2.76x10^7$ kg/yr. Current information on incinerator-related generation of 1,1,2,2-tetrachloroethane could not be identified.

According to TR193 (1995) an estimated total of 28,203 pounds (12,820 kg) of 1,1,2,2-trichloroethane (amounting to 90.6% of the total environmental release) was discharged to air from manufacturing and processing facilities in the United States in 1993. These releases were associated with 15 manufacturing or processing facilities. The reported releases in 1993 were much lower than the 64,25 1 pounds (29,138 kg) in releases into the air reported in 1991 (TR191 1993). The TRI data (Table 5-1) should be used with caution since only certain types of facilities are legally required to report and, therefore, this list is not exhaustive.

5.2.2 Water

Though no longer representing current conditions, a comprehensive waste water survey conducted by the Effluent Guidelines Division of the EPA (Shackelford et al. 1983) documented that 1,1,2,2,-tetrachloroethane has been detected in a variety of waste water discharges. Approximately 4,000 samples of waste water from a broad range of industrial facilities and publicly owned treatment works (POTWs) were analyzed in this survey.

According to the TR193 (1995), an estimated total of 2,930 pounds (1,331 kg) of 1,1,2,2-trichloroethane (amounting to 9.1% of the total environmental release) was discharged to water from manufacturing and processing facilities in the United States in 1993. This would represent a very slight increase in the amounts released to water from 1991 when 2,102 pounds (953 kg) were reported as releases to water (TR191 1993). The TRI data (Table 5-l) should be used with caution since only certain types of facilities are required to report and, therefore, the list is not exhaustive.

5.2.3 Soil

1,1,2,2-Tetrachloroethane is released to soil when it is disposed of in landfills. Another possible mode of release to soil is from accidental spills of products or wastes containing 1,1,2,2-tetrachloroethane

during overland transportation. Many releases to soils and landfills may have involved mixed wastes containing small amounts of 1,1,2,2-tetrachloroethane along with other chemicals, which makes it virtually impossible to estimate overall release levels to the soil. Since it is volatile or can be readily transformed to such other compounds as TCE, 1,1,2,2-tetrachloroethane would not be expected to accumulate in sediments (HSDB 1996).

According to the TR193 (1995) only a single pound (0.4 kg) of 1,1,2,2-tetrachloroethane was discharged to soil from reporting facilities in the United States in 1993, amounting to less than 1% of the total releases to the environment. As noted above in Section 4.4, negligible levels of land disposal would be expected at present since RCRA discourages land disposal of 1,1,2,2-tetrachloroethane and similar halogenated wastes. The TRI data (Table 5-1) should be used with caution since only certain types of facilities are required to report and, therefore, the inventory is not an exhaustive list.

5.3 ENVIRONMENTAL FATE

5.3.1 Transport and Partitioning

Most of the 1,1,2,2-tetrachloroethane that is released to the environment enters the atmosphere, where it is fairly stable in the lower atmosphere. Older research summarized in the Hazardous Substance Database (HSDB 1996) has suggested half-disappearance times of >2 years in the troposphere, while more recent studies suggest a half-life of approximately 53 days (Atkinson 1987). In either event, these residence times are long enough to allow atmospheric transport over large multi-state regions. Some of the 1,1,2,2-tetrachloroethane eventually will be transported to the stratosphere by processes such as diffusion, where it will then photodegrade rapidly. 1,1,2,2-Tetrachloroethane that is released into surface water will be lost by volatilization in a period of days to weeks. Based on a calculated Henry's law constant of 4.7×10^{-4} atm-m^3/mol (Mackay and Shiu 1981), the volatilization half-life of 1,1,2,2-tetrachloroethane (assuming first-order decay kinetics) from a model river 1 m deep flowing 1 m/set with a wind of 3 m/sec is estimated to be 6.3 hours (HSDB 1996; Thomas 1982). In waste water treatment plants that receive volatile compounds such as 1,1,2,2-tetrachloroethane from industrial discharges or other sources, air stripping is an important mechanism for transferring the chemical from the water into the air. Air stripping technologies involve cascading waste waters over trickling towers, the use of spray devices to convert the fluids into droplets or aerosols, and other techniques to increase the ordinary volatilization processes across liquid surfaces. In stripping, as opposed to ordinary

volatilization, the liquid and gas phases are dispersed. As a result, the interfacial surface area is much greater and liquid/gas mass transfer is greatly enhanced. Stripping, not biodegradation, was found to be responsible for removing 96% of the 1,1,2,2-tetrachloroethane in tests performed with activated sludge reactors (Kincannon et al. 1983). The half-disappearance time for 1,1,2,2-tetrachloroethane removal by stripping was 0.3 hour. In view of its moderate vapor pressure and low adsorptivity to soil, 1,1,2,2-tetrachloroethane would be expected to readily volatilize from soil surfaces.

The K_{OC} of 1,1,2,2-tetrachloroethane is 46 in a silt loam soil (Chiou et al. 1979). The partitioning to a soil poor in organic carbon soil removed less than 5% of the original 1,1,2,2-tetrachloroethane (Whitehead 1987). These results suggest that 1,1,2,2-tetrachloroethane will not adsorb appreciably to soil, suspended solids, and sediment.

The bioconcentration factor (BCF) of 1,1,2,2-tetrachloroethane in bluegill sunfish was found to be 8 in a 16day experiment (Barrows et al. 1980). This value is in reasonable agreement with bioconcentration factors of 21-36 estimated by regression analysis with K_{OW} ,(Veith et al. 1980). A bioconcentration factor of 2.0 for 1,1,2,2-tetrachloroethane in fathead minnows has been reported (ASTER 1995). Bioconcentration in fish is only considered to be significant when chemicals have BCF values greater than 500-1,000. Therefore, these results indicate that there is little tendency for 1,1,2,2-tetrachloroethane to bioaccumulate in fish and other aquatic organisms.

5.3.2 Transformation and Degradation

5.3.2.1 Air

1,2,2,2-Tetrachloroethane is nonreactive in the troposphere. Its primary reaction in the atmosphere is expected to be with photochemically produced hydroxyl radicals. The rate of this reaction has not been experimentally determined, but estimates of the rate can be made from structure-activity relations. Recent theoretical estimates of the atmospheric half-life (assuming first-order decay kinetics) of 1,1,2,2-tetrachloroethane as a result of its reaction with the average atmospheric concentration of hydroxyl radicals is 53.3 days (Atkinson 1987). Earlier research yielded estimates of a half-life for the reaction with photochemically produced hydroxyl radicals of >800 days, or <0.1% loss per 12-hour sunlit day (Singh et al. 1981). If 1,1,2,2-tetrachloroethane can be transported to the stratosphere, 1,1,2,2-tetrachloroethane will be photolyzed by ultraviolet light of shorter wavelength than available in

the troposphere to produce chlorine radicals (EPA 1979; Spence and Hanst 1978), which may react with ozone, thus affecting the stratospheric ozone layer. However, based on an estimated half-life and a tropospheric-to-stratospheric turnover time of 30 years (EPA 1979), it has been predicted that less than 1% of tropospheric 1,1,2,2-tetrachloroethane would eventually reach the stratosphere.

5.3.2.2 Water

1,1,2,2-Tetrachloroethane undergoes base-catalyzed hydrolysis in water at commonly encountered environmental pH values to form trichloroethylene (Cooper et al. 1987; Haag and Mill 1988). Investigators measured the hydrolysis rate over a range of pHs. The half-life at 25 “C and at pH 7.0 calculated from the second order rate equation in one study was 102 days (Cooper et al. 1987). The second study was conducted using solutions of a much lower ionic strength that is more typical of groundwater. Empirical half-disappearance times of 573 days at pH 6.05 and 36 days at pH 7.01 were obtained (Haag and Mill 1988). Similarly, researchers at Dow Chemical Company found that at ppm concentrations, 1,1,2,2-tetrachloroethane undergoes abiotic transformation to trichloroethylene in a sterile, anaerobic solution at pH 7.0 (Klecka and Gonsior 1983). By 28 days, 25% of the chemical had degraded. Hydrolysis of 1,1,2,2-tetrachloroethane was not affected by contact with the low-carbon aquifer materials associated with groundwater. 1 ,1,2,2-Tetrachlorethane in pore-water extracted from sediments showed a 29.1-day half-life at pH values between 7.0 and 7.5 (Haag and Mill 1988). In an anoxic sediment-water system (pH unreported) the half-life of 1,1,2,2-tetrachloroethane with both chemical hydrolysis and biotic degradation operative was 6.6 days (Jafvert and Wolfe 1987).

Results of aerobic biodegradability tests are conflicting. One study, in which 5 and 10 ppm of the chemical were incubated with sewage seed for 7 days, followed by 3 successive 7-day subcultures, found no significant degradation under aerobic conditions (Tabak et al. 1981). Other investigators obtained 41% degradation in 24 days in an unacclimated biodegradability test at an initial concentration of 4.4 ppm and no degradation in 5 days with an acclimated seed at an initial concentration of-0.85 ppm (Mudder and Musterman 1982). A 19% loss was obtained ina 5-day river die-away test using an acclimated system with an initial concentration of 17.3 ppm. None of the other chlorinated ethanes and ethenes in the study were found to be biodegradable. Many researchers,

however, would attribute most losses involved with sewage treatment to air-stripping processes and not biodegradation (Kincannon et al. 1983).

5.3.2.3 Sediment and Soil

Based on limited information identified in the literature, both hydrolysis and anaerobic biodegradation appear to be significant transformation processes in soils and sediments

In a study of the transformation of various chlorinated ethenes and ethanes under conditions simulating soil conditions of landfills, 1,1,2,2-tetrachloroethane was transformed into such products as 1,1,2-trichloroethane, trichloroethene, cis- 1,2-dichloroethene, trans- 1,2-dichloroethene, 1,1-dichlorethene, and vinyl chloride. Samples were incubated for six weeks under anaerobic conditions after inoculation with a microorganism culture obtained from the anaerobic digester of a municipal waste water treatment facility (Hallen et al. 1986). These transformations were attributed in large measure to the anaerobic microorganisms. In another study, the transformation of 1,1,2,2-tetrachloroethane in sterilized, sediment-extracted pore water containing 1,1,2,2-tetrachloroethane was investigated (Haag and Mill 1988). After a 6-day period, approximately 34% of the original 1,1,2,2-tetrachloroethane had been transformed where the pH was 6.05 and the temperature was 25 °C; at the same temperature and at a pH of 7.01, 74% of the 1,1,2,2-tetrachloroethane was converted. In this experiment, the transformation was attributed primarily to hydrolysis. The sediment was a low-carbon sandy material, and there was little observed sorption of 1,1,2,2-tetrachloroethane to the sediment.

5.4 LEVELS MONITORED OR ESTIMATED IN THE ENVIRONMENT

Reliable evaluation of the potential for human exposure to 1,1,2,2-tetrachloroethane depends in part on the reliability of supporting analytical data from environmental samples and biological specimens. In reviewing data on 1,1,2,2-tetrachloroethane levels monitored in the environment, it should also be noted that the amount of chemical identified analytically is not necessarily equivalent to the amount that is bioavailable.

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5.4.1 Air

Background levels of 1,1,2,2-tetrachloroethane measured in the troposphere have ranged from ≤0.1 to 0.4 ppt (Class and Ballschmiter 1986). Two air samples from rural areas of the United States did not contain detectable levels of the chemical (Brodzinsky and Singh 1982). In data collected in the late 1970s to early 1980s at 853 urban/suburban sites in the United States, the median sample concentration of 1,1,2,2-tetrachloroethane was 5.4 ppt, with values ranging from less than detection limits to a maximum of 4,800 ppt (Brodzinsky and Singh 1982). More information has subsequently been added to this database, bringing the sample size for 1,1,2,2-tetrachloroethane to 1,011 monitoring records (Shah and Heyerdahl 1988). With the addition of the new data, the overall median was computationally at or below the database lower detection limit value of zero; 75% of the samples showed concentrations less than or equal to 8 ppt. 1,1,2,2-Tetrachloroethane was infrequently found in the air of New Jersey cities; it was found in 9 of 38 samples in Newark, 1 of 37 samples in Elizabeth, and 4 of 35 samples in Camden in the summer of 1981 (Harkov et al. 1983), and in 4 out of 105 samples from the same 3 cities in the winter of 1982 (Harkov et al. 1987). Mean concentrations of 1,1,2,2-tetrachloroethane in major U.S. cities listed in other reports ranged from trace levels below detection limits to 57 ppb (Harkov et al. 1981, 1983; Lioy et al. 1985; Singh et al. 1981, 1982).

The only data on indoor levels of 1,1,2,2-tetrachloroethane were contained in a study of eight homes in Knoxville, Tennessee, obtained during the winter (Gupta et al. 1984). Ten of 16 samples (detection limits were not reported) contained 1,1,2,2-tetrachloroethae, with a mean concentration of 13.0 $\mu g/m^3$ (1.8 ppb). Although the source of the chemical was not investigated, the contamination might be attributed to consumer products used in the home or to outgassing of the chemical from construction material or household furnishings.

An EPA study of the indoor-air pollution potential associated with 1,159 common household products (Sack et al. 1992) included 1,1,2,2-tetrachloroethane as one of 31 volatile organic compounds selected for analysis. 1,1,2,2.-Tetrachloroethane was found in 216 of these products. It was especially common, in trace amounts, in adhesives, oils, greases, and lubricants. Concentrations in the products were uniformly near detection limits (detection limits not reported). Although trace amounts were present in a wide variety of products, Sack et al. (1992) concluded that 1,1,2,2-tetrachloroethane has a low potential to pose unacceptable human exposure risks in indoor air.

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The ranges of mean and maximum air concentrations of 1,1,2,2-tetrachloroethane in air at 5 NPL hazardous waste sites in New Jersey were 0.01-0.59 and 0.17-11.38 ppb, respectively, while the corresponding values for an urban landfill receiving municipal waste and non-hazardous industrial waste were 0.01 and 0.19 ppb (LaRegina et al. 1986). Samples of air surrounding the Kin-But waste disposal site near Edison, New Jersey contained up to 2.1 ppb of 1,1,2,2-tetrachloroethane. Air concentrations of 0.226 ppb of 1,1,2,2-tetrachloroethane were found in Iberville Parish, Louisiana along the Mississippi River, where many organic chemical production and storage facilities are located (Pellizzari 1982).

5.4.2 Water

Representative samples of surface water from New Jersey were analyzed during 1977-79 (Page 1981). These samples were collected from urban, suburban, and rural areas showing every type of land use common in the state. Sixty-seven of the 608 surface water samples (11%) contained 1,1,2,2-tetrachloroethane in concentrations as high as 3.0 ppb. Concentrations of 1,1,2,2-tetrachloroethane in United States surface waters reported in several studies range up to 9 ppb (EPA 1977, 1980d; Konasewich et al. 1978; Ohio River Valley Sanitation Commission 1980; Page 1976). In an analysis of ambient surface water data from EPA's national STORET database (Staples et al. 1985), samples with concentrations above detection limits were noted in 5% of the available samples, with the median 1,1,2,2-tetrachloroethane concentration being about 5.0 ppb.

Representative samples of groundwater from New Jersey were also analyzed during 1977-79 in a project summarized in Page (1981). Sixty-four of the 1,072 groundwater samples (6%) contained 1,1,2,2-tetrachloroethane, with concentrations as high as 2.7 ppb. 1,1,2,2-Tetrachloroethane has been detected in 10 private wells in Rhode Island at a concentration range of 1-2 ppb (RIDH 1989). An example of groundwater pollution by an industrial source is the case of an abandoned organic chemical manufacturing facility in Salem, Ohio that operated from 1961 to 1973 (Khourey et al. 1984). Maximum concentrations of 1,1,2,2-tetrachloroethane were 0.501-43.0 ppm in 5 on-site monitoring wells and 0.556 ppm in an off-site private well.

In the only study of rainwater located in the literature, 1,1,2,2-tetrachloroethane was not found in nine rain events in Portland, Oregon, during the spring and fall of 1982 (Pankow et al. 1984).

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There is limited information on the occurrence of 1,1,2,2-tetrachloroethane in ambient surface water or groundwater used as drinking water supplies for community water supply systems. A study of 30 Canadian public water treatment facilities did not show levels of 1,1,2,2-tetrachloroethane above a 1 ppb detection limit (Otson et al. 1982). In a United States Groundwater Supply survey, none of the 945 water supplies derived from tested groundwater sources contained 1,1,2,2-tetrachloroethane at the sensitivity limit of 0.5 ppb (Westrick et al. 1984). It was detected in 1 of 13 drinking water wells in Tacoma, Washington (Shilling 1985). It was not found in any of the 1,174 community wells and 617 private wells in a Wisconsin survey conducted in the early 1980s (Krill and Sonzogni 1986).

Analysis of ATSDR's HazDat database (HazDat 1996) shows that of 273 current and past NPL sites at which 1,1,2,2-tetrachloroethane was detected, 174 have 1,1,2,2-tetrachloroethane in groundwater.

5.4.3 Sediment and Soil

Limited information was located on general background levels of 1 ,1,2,2-tetrachloroethane in soils and sediments, with most studies focusing on problems associated with the remediation of waste sites. In an analysis of test wells around RCRA disposal sites, 1,1,2,2-tetrachloroethane was documented at levels above detection limits at 25 of 479 sites from a national sample (Plumb 1991). At one waste disposal site in Pennsylvania (Sable and Clark 1984), the concentration of 1,1,2,2-tetrachloroethane in a soil sample was 2.4 ppm. In an analysis performed on sediment monitoring data from rivers, lakes, and other aquatic systems contained in EPA's national STORET database, less than 1% of the samples contained 1,1,2,2-tetrachloroethane levels above the detection limits (generally around 5 µg/kg) (Staples et al. 1985). Based on ATSDR's HazDat database (HazDat 1996), at least 47 of 273 current or past NPL sites with 1,1,2,2-tetrachloroethane contamination showed the chemical in soil or sediment media.

5.4.4 Other Environmental Media

The data on 1,1,2,2-tetrachloroethane in fish or other biotic tissue samples are very limited. HazDat (1996) indicates 1,1,2,2-tetrachloroethane was found in tissue samples from a fish at one NPL site in Ohio. This site is on the Ashtabula River watershed. Examination of EPA's Fish Consumption Advisory Database (EPA 1995a) showed an advisory in effect for all species of fish on the lower Ashtabula River. Such fish consumption advisories are issued by states if there is some concern over the management of risks from the public eating fish caught in rivers and other water bodies. While

the management of risks from the public eating fish caught in rivers and other water bodies. While the pollution issues in the Ashtabula River have led to cautionary warnings in the consumption of locally caught fishes, available information on bioconcentration factors summarized in Section 5.3.1 above does not suggest a tendency for 1,1,2,2-tetrachloroethane to bioconcentrate, biomagnify, or bioaccumulate in the tissues of fish or shellfish.

5.5 GENERAL POPULATION AND OCCUPATIONAL EXPOSURE

The general population may be exposed to 1,1,2,2-tetrachloroethane in ambient air, by ingesting contaminated drinking water, or upon dermal exposure to contaminated soil. Since concentrations of 1,1,2,2-tetrachloroethane in drinking water in broadly based surveys have been at or below detection limits, the level to which the general population is exposed appears to be very low. While 1,1,2,2-tetrachloroethane levels in ambient air are generally low, exposures are possible in areas around incinerators or cement kilns. Modeling estimates were made of 1,1,2,2-tetrachloroethane exposure due to inhalation and ingestion of contamination produced by incinerating chlorinated solvent waste at incinerator facilities at sites in southern California, the central Midwest, and the northern Midwest (Travis et al. 1986). For the California site, the average individual inhalation and ingestion intake was 774 and 285 µg/year, respectively. While food intake accounted for 27% of the total individual dose at the California site. this contribution was 60 and 65% for the 2 Midwestern sites.

A National Occupational Exposure Survey (NOES) conducted by NIOSH from 1981 to 1983 estimates that 4,143 workers are potentially exposed to 1,1,2,2-tetrachloroethane in the United States (NOES 1991). Of these estimated exposures, 3,665 were in occupations involving work in chemical research and development laboratories with the other exposures involving jobs in industrial chemical plants. The estimate is provisional since all the data for trade name products which may contain 1,1,2,2-tetrachloroethane have not been analyzed. The NOES study was based on field surveys of 4,490 facilities and was designed as a nationwide survey based on a statistical sample of virtually all workplace environments in-the-united States where 8 or more persons are employed (based on all Standard Industrial Classification (SIC) code workplace types except mining and agriculture) (Sieber et al. 1991). The NOES database does not contain information on the frequency, concentration, or duration of exposure; the survey provides only estimates of workers potentially exposed to chemicals in the workplace.

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According to OSHA (1991), the current S-hour TWA permissible exposure level for 1,1,2,2-tetrachloroethane is 1 ppm. According to NIOSH (1992), the recommended exposure level for a I0-hour TWA is 1 ppm (7 mg/m^3) 1,1,2,2-tetrachloroethane.

5.6 POPULATIONS WITH POTENTIALLY HIGH EXPOSURES

Exposures are possible for individuals living near waste disposal facilities where 1,1,2,2-tetrachloroethane site contamination has occurred. Higher inhalation exposures would also occur in workers at petrochemical plants where 1,1,2,2-tetrachloroethane is still used as a chemical intermediate. Other populations with higher exposures would include people living close to NPL or other waste sites where leachates or runoff from contaminated soils could affect groundwater used for drinking water. In at least one instance, pollution from a large NPL site in Ohio has resulted in a fish consumption advisory for local recreational and subsistence fishers.

5.7 ADEQUACY OF THE DATABASE

Section 104(i)(5) of CERCLA, as amended, directs the Administrator of ATSDR (in consultation with the Administrator of EPA and agencies and programs of the Public Health Service) to assess whether adequate information on the health effects of 1,1,2,2-tetrachloroethane is available. Where adequate information is not available, ATSDR, in conjunction with the NTP, is required to assure the initiation of a program of research designed to determine the health effects (and techniques for developing methods to determine such health effects) of 1,1,2,2-tetrachloroethane.

The following categories of possible data needs have been identified by a joint team of scientists from ATSDR, NTP, and EPA. They are defined as substance-specific informational needs that if met would reduce the uncertainties of human health assessment. This definition should not be interpreted to mean that all data needs discussed in this section must be filled. In the future, the identified data needs will be evaluated and prioritized, and a substance-specific research agenda will be proposed.

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5.7.1 Identification of Data Needs

Physical and Chemical Properties. The physical and chemical properties of 1,1,2,2-tetrachloroethane are well characterized and allow prediction of the environmental fate of the compound (see Table 3.2). No additional studies are required at this time.

Production, Import/Export, Use, Release, and Disposal. According to the Emergency Planning and Community Right-to-Know Act of 1986, 42 U.S.C. Section 11023, industries are required to submit chemical release and off-site transfer information to the EPA. The Toxics Release Inventory (TRI), which contains this information for 1991, became available in May of 1992. This database will be updated yearly and should provide a list of industrial production facilities and emissions. Currently, reports based on TRI (EPA 1995b) provide virtually the only source of quantitative information on production levels or release levels to the environment (as a by-product or chemical intermediary) for 1,1,2,2-tetrachloroethane. Additional mechanisms to supplement this TRI information rank as a major data need.

Production methods and uses for 1,1,2,2-tetrachloroethane are documented (Archer 1979; HSDB 1996; IARC 1979), but there is no recent detailed breakdown of the percentage of production consumed by each use category. Figures on current exports are also lacking. Approximately 440 million pounds (199 million kg) of 1,1,2,2-tetrachloroethane were produced in the United States in 1967 (Konietzko 1984). Production declined markedly thereafter, falling to an estimated 34 million pounds (15 million kg) by 1974. While 1,1,2,2-tetrachloroethane is apparently no longer produced as a final product, it may occur as a chemical intermediate or waste product in the manufacture of other chemicals (CEPA 1993; HSDB 1996). Better quantitative measures of current production, including production for export, is a data need for estimating the potential for environmental releases from various industries, as well as potential concentrations in the environment. Knowledge of which consumer products contain 1,1,2,2-tetrachloroethane is also a data need for estimating general population exposure. Unfortunately, this type of detailed information is difficult to obtain since companies consider it to be confidential info-ormation. While monitoring information on discharges was gathered during the 1970s and early 1980s when the EPA was developing criteria and effluent guidelines for a number of priority pollutant toxics (Shackelford et al. 1983), the Toxics Release Inventory now constitutes the only major broad-based survey of releases to the environment. According to the most recent TRI information (TR193 1995), releases to the air and water still continue from processing facilities in the United

States. At present, the TRI data only cover major industrial sectors, so some releases may go unreported. Possible expansions of the types of facilities required to submit information under the TRI reporting requirements could help make this source of information more comprehensive.

While regulatory coverage for halogenated organic wastes has become increasingly more well defined (EPA 1989), record keeping under RCRA procedures works best when a chemical is a major constituent in a waste. Since 1,1,2,2-tetrachloroethane is now usually a minor component in other waste materials, there is often little documentation of the amounts of 1,1,2,2-tetrachloroethane entering waste disposal sites. Since 1,1,2,2-tetrachloroethane is still encountered at 273 of 1,430 current or past NPL sites (HazDat 1996), better quantitative estimates of amounts entering active disposal sites would be a legitimate data need.

Environmental Fate. 1,1,2,2-Tetrachloroethane is quite volatile; but the highest potential for persistent pollution is when the chemical has been introduced into sediments and groundwater (Atkinson 1987; HSDB 1996; Mackay and Shiu 1981). While the chemical can be biodegraded under anaerobic conditions (Bouwer and McCarty 1983), there are major differences under aerobic conditions (Tabak et al. 1981). Further investigation would be helpful to resolve the discrepancies in the aerobic degradation data for 1,1,2,2-tetrachloroethane and would rank as a major data need.

Bioavailability from Environmental Media. Based on available animal studies (Mitoma et al. 1985; Morgan et al. 1970; Yllner 1971) and inferences from studies of similar low molecular weight chlorinated alkanes in humans, inhalation, ingestion, and dermal exposure are the major routes of exposure (Pellizzari et al. 1982). 1,1,2,2-Tetrachloroethane in air and/or water can be expected to be absorbed readily into the systemic circulation, and 1,1,2,2-tetrachloroethane in soil may be absorbed to some extent through the skin. Analyses of 1,1,2,2-tetrachloroethane and its stable metabolites in body fluids and tissues of people exposed to the chemical is a data need to improve the knowledge base on the bioavailability of 1,1,2,2-tetrachloroethane.

Food Chain Bioaccumulation. Given its tendency to either volatilize to the atmosphere (Atkinson 1987; HSDB 1996; Mackay and Shiu 1981) or become transformed into such other chemicals as TCE (Cooper et al. 1987; Haag and Mill 1988), 1,1,2,2-tetrachloroethane shows little potential for bioaccumulation. While there are some minor discrepancies between observed bioconcentration factors (Barrows et al. 1980) and estimates predicted from regression analyses

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(ASTER 1995; Veith et al. 1980), 1,1,2,2-tetrachloroethane shows no significant tendency to bioconcentrate and is not considered to show significant potential to bioaccumulate in food chains. No major data needs are apparent for this information category.

Exposure Levels in Environmental Media. In studies based on monitoring data from the late 1970s and early 1980s, 1,1,2,2-tetrachloroethane concentrations in receiving waters (primarily rivers) of at least 10 ppb were documented in approximately 10% of the samples collected in a national study of runoff from urban areas, with a maximum reported concentration of 1,400 ppb (Cole et al. 1984). In soils and sediments, information from NPL sites shows detections at 273 of 1,430 sites. Since the treatment, storage, and distribution processes used in large community drinking water systems will generally release volatile chemicals to the air, 1,1,2,2-tetrachloroethane concentrations in public drinking water are generally very low. The chemical has been detected in untreated groundwater formations used for private wells in some parts of the country (Page 1981; RIDH 1989). The highest levels have been found in groundwater in the vicinity of waste disposal sites (Khourey et al. 1984). Background levels of 1,1,2,2-tetrachloroethane in the air are typically less than 0.4 ppt (Brodzinsky and Singh 1982; Class and Ballschmiter 1986). Limited data collected in the vicinity of waste disposal sites has shown ambient air levels considerably higher (from >l ppb to as high as 2.1 ppb) (Gupta et al. 1984; LaRegina et al. 1986).

It is important to have recent data concerning the levels of this chemical in the atmosphere as well as in soils, sediment, groundwater, and surface water to determine background concentrations and exposure levels. Reliable monitoring data for the levels of 1,1,2,2-tetrachloroethane in contaminated media at hazardous waste sites are needed, so that the information obtained on levels of 1,1,2,2-tetrachloroethane in the environment can be used in combination with the known body burdens of 1 ,1,2,2-tetrachloroethane to assess bioavailability and potential risks of adverse health effects in populations living in the vicinity of hazardous waste sites.

Exposure Levels in Humans. Information on exposure levels in humans is extremely limited, with most conclusions on health effects being based on inferences from animal studies (Yllner 1971). General population and occupations exposure levels have been based on models (Travis et al. 1986) or provisional estimation techniques (NOES 1991). Improved information on human exposure levels is therefore a data need. This information is necessary for assessing the need to conduct health studies on these populations.

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Exposure Registries. No exposure registries for 1,1,2,2-tetrachloroethane were located; it is not currently one of the compounds for which a subregistry has been established in the National Exposure Registry. The substance will be considered in the future when chemical selection is made for the establishment of subregistries. The information that is amassed in the National Exposure Registry facilitates the epidemiological research needed to assess adverse health outcomes that may be related to exposure to this substance.

5.7.2 Ongoing Studies

No information was found to indicate that there are studies in progress that relate to the environmental fate of 1,1,2,2-tetrachloroethane (FEDRIP 1995). Similarly no ongoing monitoring or exposure studies were identified.